Notebook, N-87-12-00

This notebook covers the period December 1887-December 1889. The book contains notes, drawings, and calculations by Charles Batchelor and Arthur E. Kennelly regarding the multipolar dynamo, phonograph motors and magnets, and electrical meter and battery experiments. There are also notes by an unidentified experimenter relating to the electrical distribution system in Llewellyn Park and to other Galvanometer Room projects. The front cover is labeled "#497" and is inscribed "Multipolar Dynamo." The spine is labeled "44." The pages are unnumbered. Approximately 90 pages have been used.

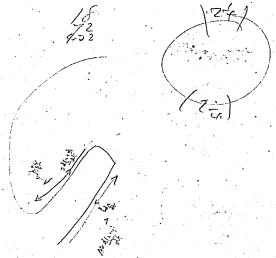
xE-172 N-87-12-00

Dec 1887

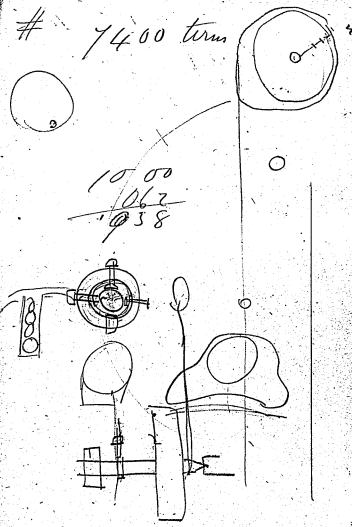
497

5 7/16

4 1/2



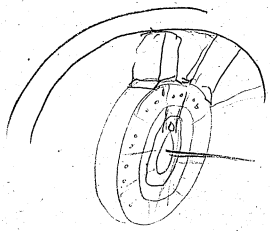
7400 turn

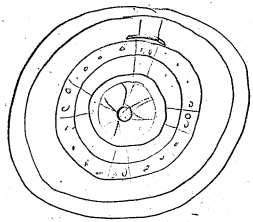


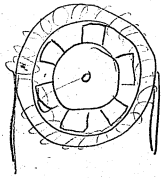
10 00

1062

1038

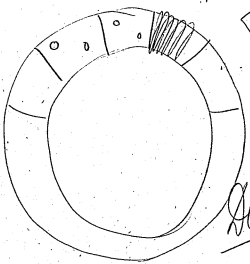


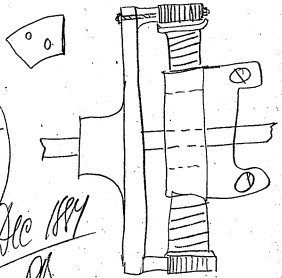




1881

each plate thus shape





Dec 1894
OS

M #1 Magnetic line to break 42-1

$L = \frac{8'' \times 2 \times 6 \times 22 \times .74}{2 \times 12 \times 7} =$ feet active

$= 8 \times 22 \times .74$ 130 feet

$V = \frac{4.9 \times 3.14 \times 1900}{12'' \times 60} =$ feet per second

40 ft per sec.

$I = \frac{125}{L \times V} = \frac{125}{130 \times 40} = .024$ M I

27/Jan/88

7"

8

10½

7½

Jan 17 1888.

Multipolar Dynamo.

Winding Inside diameter

Space $13.5 \times 3.14 - .5'' \times 36 =$

$42.39 - 18'' = 24.39$

M = Mq a #1 + 25%. Mq #1 -

$V = \frac{30'' \times 3.14 \times 1000 \text{ Rev.}}{12 \times 60} = 91$ ft per sec

I = Given that the wire on armature will carry at least 15% more current owing to being a fan blowing at much greater rate & forcing the air greatly —

∴ #15 .072 will carry 40 amperes as placed in #1 —

We can therefore say 250 circ mils per amp.

Now for each ⅙ to carry 60 Amp. each wire is 15000. or #13. wire (.0925).

~~Here~~ Room on armature for ~~[illegible]~~ ~~[illegible]~~ for each section ~~of [illegible]~~)

~~[illegible]~~ We want 40 spires on ~~[illegible]~~ 3 sections of 1.85" each

∴ 5.55

·0008688
585
4440
4500
6960
4500
·50 8 2440

·0372.

M = ·024 + 25% = ·030

V = 91 ft per sec. What length?

$\frac{125}{·030 \times 91}$ = L 45 ft about

Active length ·13" per turn

Dead " 7"

We want 40 spires

∴ Space = 5·155

Wire #13 B.W.G. ·095 + 15 = 110

48 turns of #13 B.W.G.

16 turns in each place

Better still 45 turns of #12 ·124

15 in each pocket

50 ft of 12 #12 = 132·672 Cmc

mile = ·00357 Resis.

at 400 Amp = 330 cmc per amp

Rad. Surface side 283 + 283 + edge 742.
1308 incl

H.V. = $400^2 \times .00357 = 571$

per ☐" .45

1 wire down to each 3 turns
36 x 5 = 180 blocks

See date
April 4, 1888
2 pages attached
Further

Aug 4th 1884

New Calculations for
Multipolar dynamo.

Binge pieces that hold the iron of Armature have been increased from 1/2" to 5/8 so now the wire space is:-

~~[illegible]~~

~~[illegible]~~

$2\frac{1}{4} \times 3.14 - .625 \times 26 = 62.28''$

Wire Space for each pair of PHN Mag.

$\frac{62.28}{6}$ $10.38''$

$\frac{10.38''}{6} = 1.73''$ each section

3 of these sections make the passage of the positive ones

3 make the negative

Now assuming M as equal to ·030 and I as 91 feet per second then

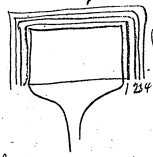
$$\frac{\text{Volts } 125}{\cdot 030 \times 91} = \text{length of wire} = 45^{ft}$$

Now 45^{ft} of wire must go in 3 spaces so that is 15 feet in each space

each space is 1·73 and one turn has 13" effective wire say 12" then we want 15 to each space $\frac{1 \cdot 73}{15} = \cdot 115$ therefore wind it with #12.

Ordered #12 armature wire 1000 feet

Space occupied by wire

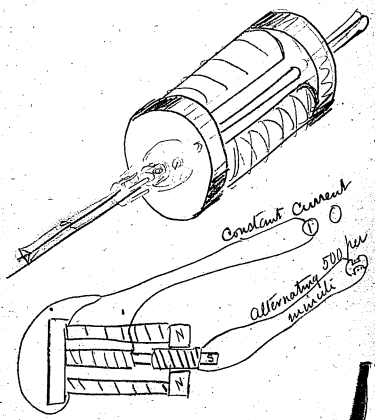


	1 Insulation Tape + 2 Oiled papers	.009
2	Wire	.129
3	Mica	.020
	Wire & clip	.026
	Space	.125
		.309

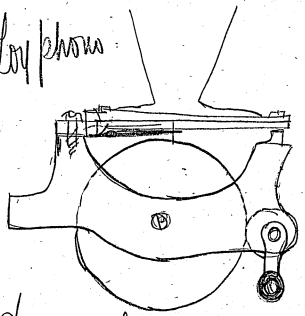
.3 on each side

end Apl 4 1888

Coal Drill Apl 4th 1888
DS



Toy phone



Single wheel —
One revolution says all —
No Screw.

April 4 1886
CD

21.

150
20
3000
60 | 2500
4

-150 Ker-

18 4.5 | 9/4 2

6.5
31.5
260
65
19.5
20.410

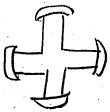
4.5
22.5
10.125

18.

Phonograph Motor May 10 1888.

Magnet:-

each 2¼" × 2" × 1¼"



#21 B.W.G. ½ layers in each spool arm)
2¼" long = 8 ohms.

Ring-
#23 B.W.G. 35 to the inch
(.025")(.037) cm.

Amp turn per C1 =
35 × 4.5 = 158 turn
2.25 C 1
158/2.25 = 70 Amp turn to Cubic I
(#1 Magnet has only 26)

Cutting Speed 4 feet per Second

Ampere turns per Cubic" in Cores of #1.

2 Cores 7" x 5" diam =
19.63 x 14 = 275 cub. inches

Ampere turns =
$35\frac{1}{2}$ lb. = 323 per x $35\frac{1}{2}$ lb. = 11467. feet total

1 turn equals =
$\frac{6'' \times 3.14}{12}$ = feet = 1.57

∴ 7300 turns on magnet +
1 amp. makes 7300 amp turns

275 C1 | 7300
550
1800

26 amp turns per Cubic inch

7300
7650

3500

3500
3500
14700

5736

Multipolar Dynamos May 23 1888

Resistance Size of wires leading from Coils to Commutator

Multipolar Dy May 28 1888

Speed
690. Ran + 40 Volts without load when stopped armature 145°F by Foucault Currents

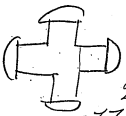
Started again 3:40 p m
135°F 45 Volts + 60 amperes with ½ the Revs. one in
after 25 minutes
150°F 45 Volts + 60 amperes
Current in armature seems to somewhat neutralize the Foucault Curr.

690 Rev is 99½ feet per sec -

Multipolar Dy. May 29 1886

Started at 11 30 a m no current on
118 feet per second
810 Rev — ran all day
perfectly steady this
trouble

Phonograph magnet May 28 1888



4 pieces
$1\frac{3}{4}'' \times 2\frac{3}{8}'' \times 7/8''$.

2 ohms to carry about
·77 ampere.

2 ohm of #18 = 464 feet. = 5568"

length of m. 7"

Enc. #18 ·064 = 16 per" — 6·5" per turn

7" = 105 turns × 6·5" = 682" per layer

$\frac{5568}{682}$ = 8 layers. of #18 —

Take #17 — 2 ohms = 342 feet = 4104" —

1 turn = 6·5"

·042 + ·015 = ·057 = 17 per"

7" = 119 turns per layer = 773"

5·5 layers of #19 —

·057 | 1000 / 570 / 430 / 399 | 17

·05 | 200 / 40

Average. 2·375 × 2·375 = 5·625 | 4104 / 4638 | 6

1·75
6·500

5568

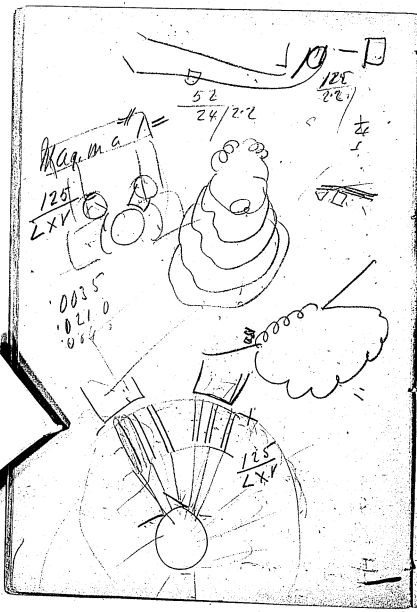
1·75
7·00

682 | 5568 / 60 | 8

·049 | 1000 / 490 / 500 | 16
·164

105
6·5
525
630
682·5

105
6·5
525
630
773·5



Multipolar transformer May 28th 1888.

Figure for pushed one as at present.
Cores $3\frac{5}{8}$" X 4" chain
Armature 3" X 1" X 12"
8 pole pieces

To transform from 1200 volts at station with 10% loss to 110 volts at transformer with x current.

Inside circumference arm.
10" X 3·14" = 31·4"
Wire takes 7·85" for each pair poles.
∴ 3·92" for each ~~coil~~ set coils.
The motor end —
Speed would be 104 ft per sec or 2000 Rev
Length would be 52 feet active.
— Mag same as #1.

Space 3·92 =

~~104 feet active~~

~~1 turn = 8" active & 5" bleed.~~

~~52 feet under 4" = 204 turns~~

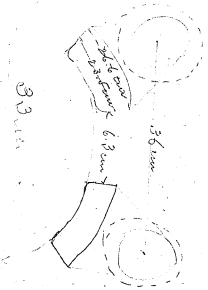
52 feet active 26 under P pole
26 under N pole

1 turn = 8"

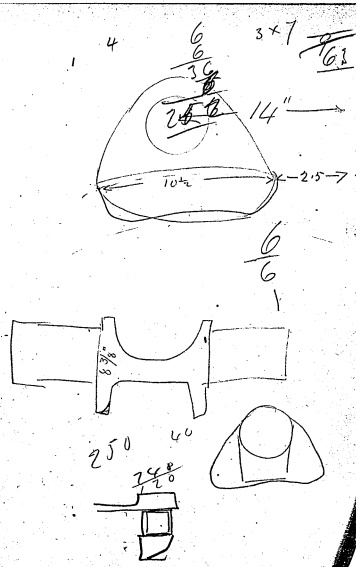
52 ft = 624 = 204 turns

204 turns in 3·92 = ·019" or giving

Out side dia. of
Curvature 33in



Poles bound out to 33.7p



16

At 1½ Amperes
103 Volts

3800
1900
5 | 10300
51.0

134
67
9 38
8040
89.78

134
89.78
1347
44.67
13 4.67
152
180
45

114

135
40
5400
45 | 1800
40

114
114
1026
114
21.66

114
92
920
920.80

92

127

Multipolar Dynamo. June 27 1888

Calculated improvement larger area
30% ∴ 130 × 1.3. = 169 Volts

Area over which field is distributed
is greater 33%
∴ 169 × .67 = 113 Volts

Add ~~to~~ the 50% more wire travelling
= 113 + 66.5 = 170

Reduce bars to 152.
Volts 170 × 152/180 = 144 Volts

~~Reduce speed to less current in field mag~~

19% loss of permeability = 144 − 1½ 136.5
∴ 1 to 10 wire 5 times current +
152 Blocks

19

Magnets for same June 27 1888

2165 ~~Anderson through the girls~~

Jeach mechanic

each cost 38¢ ~~or thereby~~ ~~Hood Anderson~~

314
33
1042
1042
11462

Bold wire diam = 1/8"

~~0.150 × 152 = 22.8"~~
15
760
152
2250

0.150 × 456
48
2250
456
6840

114.6
= 68.4"
152) 46.2 (3

0.3
.45
75
150
760
1.64
1160

Multipolar Alterations

1 Make frames 7" diam + frames ~~to~~ suit

1 Commutator 152 blocks —

Armature 1 #10 wire 3 times around

28 ft #15 wire on each core in 2 series of 8 coils

125
16
.111

3·14
12
180 | 37·68 | 0·209
36·0
1·68
1·620
180
248
209
026
183

152 | 37·680 | 0·248
304
76·8
608
1216
1216
248
026
222
183
39

Multipola Commutator June 28 1888.

Change from 180 bars to 152.

180 bars — 12" diam = ·209" per bar & insul.
Insulation = ·026" ∴ Bar = ·183" —

For 152 bars & keep the same insulation —
Bar & insulation = 37·68" ÷ 152 = ·248"
Insulation ·026" ∴ Bar = ·222".

Take 152 of the old bars and solder ·039" on each

Multipolar Dynamo. June 28 1888

New figures —

Data we have with old machine (12 core) —
With 1·5 amp passing through each core we got 105 Volts at brushes. —
Armature 1" 1/2 3 times around & 150 blocks making 6 complete machine & carrying in total 800 amperes.
Each magnet then generated 105 Volts from 30 coils of 3 turns each. or 90 turns of which 45 were passing P & 45 N at same time
Active wire in each coil = 9" = 810" ÷ 7·5
Speed was 115 ft per sec.
Volts were 105
So the M. = ·0135.

With M the same and 8 pole with 12. & with 152 Blocks & #10 wire 1 wire 3 times round (or about) have the following.
M ·0135
Speed 115 ft
Active wire 85·5 feet
then ·0135 × 115 × 85·5 = 132 Volts.
Which is wanted

Now how have we the same magnetism?
We have ·9 of the other therefore
We have 119 Volts

$20'' = 1.7$

$\frac{456}{64} \times \frac{20}{146} = 22.50 = 350$

$\frac{5.75 \times 10^{-4} \times 1.7 \times 57}{8}$

$69.7 \times 10^{-4} = .00697$
$.0008$
$.00775$

New Octopolar Dynamo June 28 1888.

Resistance of Armature

20" per turn 456 turns

$456 \div 64 = 7.1 = 142'' = 11.9$ ft

true #10 - .000575 ohms per ft

$= 6.9 \times 10^{-2} = .0069$ ohms -

This = drop 6 volts at 800 amperes.

Transformer June 28 1888

Conditions

18" Armature

1200 Rev. — 100 ft per second

6 Poles. — M = 2400 lines per square centimetre

Armature iron 5" X 1½" X 18"

1200 I & 1100 E 115 Volts

Assume Secondary

115 turns to each segment

6 Segments in all = 780 feet

#14 Wire — Resistance ~~[illegible]~~

·331 all in built arc

3 layers allowing ·2 out of 4·2 for paper

Primary — 990 turns = 1072 feet each segment = 6400 feet in all = 12 ~~[illegible]~~ (0·039) cu. = 10 layers of 100 turns — Total res. to be 3 ohms

over two pages

6000 feet of #1 on 6 1½ amp
8600 feet of " " on 6 1.

$\frac{8600}{6000} \times \frac{80}{100}$

50·2" inner circu. ÷ 6 = 8·38"
·38 for insul. = 8"
Commutator at each end 48 Blocks.
Space for winding ½" for each coil

June 30 1885

Magnet of Transformer
core 6" diam 6 long
wound with 16 lb. lbs of
#23 wire

About 100 c. on fine

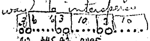
2 p

As there are to be 990 turns in the fine wire coil say 1000 = ~~50~~ turns in each segment of 1/16th of a circle there can be 40 blocks and 25 turns to each block.

As there are to be 115 turns say 120 in the coarse wire coil say 120 ~~suppose~~ 40 blocks and 3 turns to each block.

Then

This means that if the primary ~~+ secondary~~ windings alternate, there must be 100 divisions of 4 inches of an coil or $\frac{1}{25}$'' of an inch each

The diam of the course wire covered is 0·1" that of the fine 0·039 so that the only way to interperse these regularly would be 

there would be 20 divisions of the fine wire ~~and~~ making each 50 turns and 20 divs of the course making six turns and the length of a division ~~of the course~~ would be at the circumference of the ring $\frac{8\cdot4}{40} = 0\cdot21$" allowing $\frac{10}{1000}$ th inch for paper.

125 volt × 200 amp = 25000 Volts
= 25 amperes
= 4 amperes each wire
= 800 [illegible]

Altered ~~[illegible]~~ source winding of transformer from no 14 to no 18 wire in order to fit the fine wire into spaces and then split into 18 ins 2 mos 20 = 156 of feet = 6 lbs of no 20

July 20 1888

Transformer Armature Winding

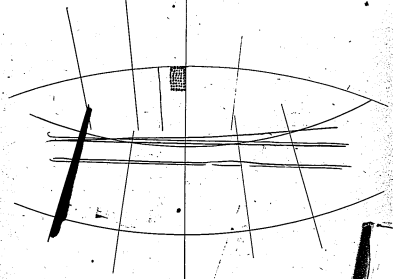
15" inside = 47·10" circ. ÷ 6 = ·785" for both ends prim. & sec.

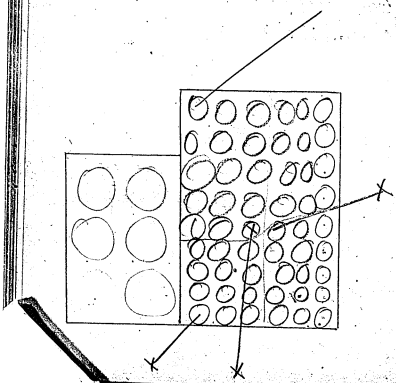
$\frac{47 \cdot 10}{6} =$ 7.85" each segment of 6 in total

Now we take M as in Multipolar at ·0135 × ·9 = ·01215 M

Then ·01215 × 100 × x (cut per sec) = 120 Volts Bad

$\frac{120}{\cdot 01215 \times 100} = x =$ 98 ft = Length.





Transformer Prim. Winding

Now Primary must give 1000 V at 10 ft per sec

so $\cdot 01215 \times 100 \times x = 1000$

Then Length $= \dfrac{1000}{\cdot 01215 \times 100} = \underline{\underline{823 \text{ feet}}}$

There are active wires ~~the length of~~ active wire of each ~~coil~~ = 9" so that

823 ft of fine = 109 turns
9 ft of coarse = 130 turns 120.

Now as we get the total Volts ~~per~~ ~~to~~ of circle it follows that there turns must go into ~~#23~~ "each 3.92"

Insulation of #23 = ·012"
" " 14 or 16 · ·015"
Insulation of paper ·004

Then 240 blocks gives ~~each coil~~ ~~[illegible]~~ = ~~[illegible]~~" for the two coils ·395 for each two [illegible] Sq.

1100 turns = about 5½ turns per block & this would divide into 24 for double blocks.

6 wires wide & insulation also a paper around as: [illegible] = ·037 × 6 + ·008 = ·230"

leaving ·165 for the coarse wire 6 per block

Then 6 #23" 9 deep for one side and 2 #16" 3 deep for the other would do ~~but~~ is out of proportion as shown —

Iron wire in each spool July 20th 1888
of the 400 to make new Armature Core
for Octopolar —

~~Average Diam 30" 3" deep = 130 turns of .022" = 12449" = 1037' =~~

Average Diam 30" = 94.24" per turn —

#26 = .018" = 0
True we have = .020" — ordered .022" = 137 turns —
137 turns × 94.24" = 12911" = 1076'
1076' of .020" wire = 1.576 lb. copper
= 1.36 — iron

add 10% = 1.5 lb. in each spool.

.135

3.95

Specific Resistance of $ZnSO_4$
Solution. 5% Hot
Surface of plate 2.04 × 3.95
Distance of separation 0.135 in.

Temp. 71°F.	Resistance true O:	6.05 Ohms	
	" to false O	5.70	
true O	Res.	5.65	40MA
false O	"	5.35	
true O	Res.	.47	160MA
false O	"	.45	
true O.		.80	2.5MA
false O		.47	

2nd trial distance 0.24

true O	temp. 70°F	1.02	4000
false O		1.00	2.5MA
true O		1.00	700 Ohm
false O		.92	10MA
true O		.81	150 O.
false O		.75	40MA
true O		.69	24 O.
false		.68	160MA

$$\frac{0.50}{0.343} \times 51.8 \qquad \frac{2.59}{0.343} = \frac{2.59 \times 10^{1}}{0.343} = 75.5$$

$$\frac{0.83}{0.61} \times 51.8$$

$$\frac{1.34}{1.17} \times 51.18$$

3 Trials dist. .46 in.

true 0	temp 69°	1.45	4000.0
false 0		1.45	
true 0		1.49	700 0
false 0		1.47	
true 0		.45	150 0
false 0			
true 0		1.15	240
false 0		1.05	

0.00001038 × 32.54

0·34	0·29
0·35	0·30
0·30	0·28
0·47	0·38
0·69	0·49
	·45
0·52	0·47
0·52	0·47
0·55	0·51
0·63	0·58
0·65	0·60
0·67	0·62
0·69	0·64
0·70	0·65
0·74	0·69
0·80	0·75
0·90	0·81

10·30 14. 9. 88

Sp g. of solution experimented with
1·063 Temp
Separation 0·09"
Leads 0·65 w

Measurement of Cp. R. & diff Temp

Time	Res. in ct	Temp	Mes	T. Z	F.Z.
11·16	2900	112°F	25	·99	·94
	720	1	10	1·00	95
	157	140°	40	·95	·95
11·28	700	100°		1·12	1·03
29	"	94		1·14	
30	"	93			110
31	"	93		1·17	112
·32	"	93		117	112
·34	"	92		120	116
·37	"	90		128	123
·38	"	88°		130	125
·40	"	86°		132	127
·42	"	84°		134	129
·44	"	82°		135	134
·47		80°		139	134
·50		79°		144	140
·53		78°		155	149

Time	Temp	TZ	FZ
1350	69°F	160	155.
·56	62°	178	173
14 03	60°	206	193
·05	57°	210	200
·10	54°	216	205
·13	52°	235	225
·18	52°	252	240
·23	50°	273	250
·26	48°	285	265
·30	45°	310	280
·35	44°	326	295
·50	42	341	315
15 ·03	41°	385	335
	Removed ice + let lamp run		
·08	42	375	345
·13	44°	262	220
·16	46°	247	222
·20	45°	241	225
·21	50°	237	217
·25	52°	231	220
·28	56°	222	210
·30	58°	213	211
·31	60°	209	
·32	62°	200	1890

Time	Temp	TZ	FZ
	66°	198	
15·33	66°	194	
	67°		175
15·34	69°	190	176
·37	70°	182	170
·40	72	175	165

Prepared some saturated $Zn\,SO_4$ partly from pure + partly from common $Zn\,SO_4$.

Density 1·41 @ 66° F

		TZ	FZ
16·38	58°	123	121
·39	57	125	
·40	56	128	118
·42	54°	133	120
·46	52	140	128
·49	50	146	130
·51	48	148	
·56	47	150	135

Took jar out of ice + brought it into air h

2:00 80

19

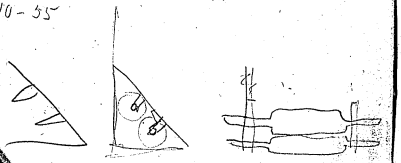
·65 15

Time	Temp	T. Z	FZ
16.55	45	149	134
17:01	50	142	130
·03	52	133	123
·04	54	132	122
·05	56	126	116
·07	58	123	111
·08	60	119	106
·09	62	115	103
·09½	64	112	101
·10	66	107	98
·11	68	105.5	96
·12	70	103	92
·12½	72	101	90
·13	74	99	89
·18	77	96.5	
·19	78	94	84
·20	80	93	83
·21	82	90.5	82
·22	84	89	80
·23	86	88	80
·24	88	86	79
·25	90	85	79
·26	92	84	79
·27	94	82	78
·28	96	81.5	77
·29	98	81	77
·30	100	80	77

Insulation of + main 17000
" " − " 18000
" " 0 " ~~18000~~
+ 16000
− 17500
0 17000

Gal. Room Switches out
Resistance between + + 0 310
" " − + 0 1020
" " + + − 1340

~~Resistance~~ Total Insulation
10 - 20 Anchor Joint Joint 1700
10 - 45 Anchor Joint + Bonds 1350
10 - 55



Transformer Test
Nov 2 '08

Resistance box ~~half out~~
Speed 190 Rev. per min
Current 0.8 amp.

Res. Box 1/4 out
Speed 225
Current .8 amp

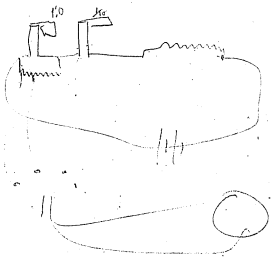
Speed 146 Res box all in. Current .8 amp
160 at Res. box 1/4 out. " .8 "
245 ~~160~~ Res. box 1/2 out. " 1.4 "

11.20	volts	1290	amperes	5.6	7224
Lamps burning		100		44	4400
11.20	volts	1280	amperes	6.3	
108 lamps		99		50	
Rector 1 Pint	40	volts	1300	-	6.4 5220
	108 lamps		100		49.5 4455

11.42 Machine stopped & municipal fuse piece carried away

$$\begin{array}{r} 1290 \\ \times\ 56 \\ \hline 7740 \\ 6450 \\ \hline 72240 \end{array}$$

$$\begin{array}{r} 384 \\ 765 \\ \hline 8066 \end{array}$$



Res. of strip alone 0.5214 ω. 100% TB
" " lead 0.0125 ω
" " strip 0.5089 ω Length

0.2420
0.0125
0.2295 Length

10.11.88 9.45

Rio of leads 0.1 1000/10 10 mm

Heated Bottle	of unvarn 25 ft	9.11.88	4.7 = 4.6
–	cool var 25 ft	7.11.88	7.55 = 7.45
heated	cooled with varn	8.11.88	17.30 = 17.20
heated	5 to var 25 ft	31.10.88	14.0 = 13.9
cool	unv 7 to cool 25	31.10.88 with bottle	8.5 = 8.4
heated	9 to 10 unvarn 25 ft	3.11.88	3.4 = 3.30
cool	3 to 4 unvarn. 25 ft	31.10.88	7.2 = 7.1
heated	1 to 2 unvarn. 25 ft	31.10.88	2.6 = 2.5

Meter ox Cast

Oct. 10-88

3 Pairs of used, 25 ft, plates filed sandpaped, and varnished as follows

A varnished all over – not amalg

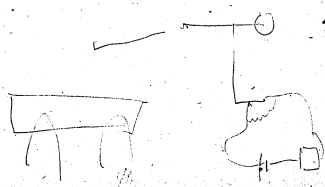
B varnished back & edges – remainder of surface amalgamated

C not varnished except top & copper rod – amalgamated

Weight with lower fitting

A	169,739	735	169,001
B	172,800	735	172,042
C	173,445	735	172,707

800 × 115 (123
715) 9200
[5.0
2600



13th Nov. 88

8.07	Commenced running 135 volts · 3 mins		21.5 amp.	160 A Def. 30
8.15	133	6 mins	20.5	275 A Def 55
8.24	133	9 mins	20.	400 A Def 77
8.23	131	13	19.5	Def. 105
8.25	127	16	19	Def 125
.30	122	19	18.5	146
.30	119	20	18.5	152
.32	116.5	20	18.0	147
.33	113	21	17.0	150
.35	125 cut out	21	22.5	157
.37	119	21	2	147
				138
.50	115	22		144
.55	113	23		145
9.15	113 87 mins	24	19.5	148
			20.5	149
.20	119	24	23	155
10.				

10.02	123 volt	24 mins	22.5 amp.	159
11.00	122 volt	24 mins	22.5 -	missed

(wind carried away).

.05	260°
.10	296
.15	298 highest

$\frac{mt}{n \text{ volts}} = N$

$At = 7300$

$\therefore A = \frac{120}{4 \times 8} = \frac{30}{R} \quad 7300 = \frac{30t}{R}$

$R = 2 \times t \times r$ where r = ω per foot

$7300 = \frac{30 \cdot t}{2 \times r} \quad \frac{15}{r}$

$r = \frac{15}{7300} = 2.055 \times 10^{-3} = \#15$ wire

$C^2R \quad \frac{C^2}{R} \times 2R$

$\frac{C^2}{R}$

30 lbs wire will make amperes $\frac{2}{3} \times 12 = 8$

amperes $\times 1^2 = 960$ watts $\div 4 = 240$ watts per magnet

N. pressure $120 \times 12 = 1440$ Watts $\div 8 = 180$

$208 \times 110 = \frac{2500}{8}$

31

30 lbs $= 30 \times 2.4 \times 10^{-3} = 72 \times 10^{-3} = .072$

$\frac{72}{2.4} = 30$

20 lbs of #15 wire =

$63727 \times 20 = 12750$ ft

$7.6 \times 81 = \frac{76}{608}$ $\quad = 616$ turns

6156

Capacity for $12 \times 616 = 7392$ turns

say 7300 temp turns

$At = 7300.$

$\frac{A}{2} = \frac{120}{8R} = \frac{15}{R} \quad \therefore 7300 = \frac{15t}{R}$

$R = \frac{2}{3} \times t \times r$ where r = ω per foot.

$15R = 7300 \times \frac{2}{3} \times t \times r$

$\therefore r = \frac{15}{14600} = \frac{1}{1000}$ $\quad$ 14600, 49000

$= 330$ $\quad$ 1000 | 3

.003 $\quad$ #21 wire

~~.0031~~ $\quad$ #12 wire

ω per foot $= 8.69 \times 10^{-6}$

600 turns $= 1200$ feet $= 1.2 \times 10^3 \times 8.69 \times 10^{-6} =$

$= 10.428 \times 10^{-3}$

$= 1.043$ ω

1000 turns $= 2000$ feet $= 2.0 \times 10^3 \times 8.69 \times 10^{-6}$

$= 1.738$ ω

$3.60 \times 10^{-3} \times 2 \times 10^3$ $\quad$ 5000.

7.2×10

$= 13.92$ ω in series

$= 3$ parallel

$At = 7200$

$A = \frac{120}{16R} = \frac{7.5}{R} = \frac{7.5}{2\pi r}$

$R = 2 \times t \times r$

$\frac{7.5t}{2\pi r} = 7200$

$\frac{3.75}{r} \cdot 7200 \cdot t = \frac{3.75}{7200} = \frac{2.75}{7.2 \times 10^3} = .52 \times 10^{-3}$

$= 5.14 \times 10^{-4}$ #19 wire between 3 & #19

30 lbs = 15.07 × 30 = 45.2 = 26 turns

45 feet × 16 = 180 × 6 = 1,080 feet in all

$= 4.78 \times 10^{-4} \times 7.20 \times 10^{2} = 35 \times 10^{-2} = .35$

360 amperes 120 × 360 = 43,200 Watts

÷ 16 = 3000 Watts per magnet

$At = 7300$

$A = \frac{120}{2R} = \frac{60}{R} \quad 7300 = \frac{60t}{R}$

$R = 2\pi r \quad 7300 = \frac{60t}{2\pi r} = \frac{30}{r}$

$r = \frac{30}{7300} = \frac{30}{7.3 \times 10^3} = 4.11 \times 10^{-3}$

#18 wire

30 lbs = X 0.592 = 17.76 each

$\frac{120}{34.52} = 3.48$ amp

3 × 16 = 48 turns

120 × 3.48 = 417 ÷ 2 = 208 Watts

30 lbs wire

at 16 in series #9 wire

3000 Watts per magnet

2 series of 8 in multiple

12 wire 2400 Watts per magnet

4 series of 4 in multiple

15 wire 2400 Watts per magnet

8 series of 2 in multiple

18 wire 205 Watts per magnet

P. 360 amperes in each = 720 amperes

P. 20.8 amperes in each = 42 amperes

P. 8 amperes in each = 32 amperes

P. 3.5 in each = 28 amperes.

$$\frac{d^2\theta}{dt^2} = a\theta$$

$$\therefore \frac{d^2\theta}{dt^2} \times \frac{2d\theta}{dt} = 2a\theta\frac{d\theta}{dt}$$

$$\therefore \left(\frac{d\theta}{dt}\right)^2 = a\theta^2 + k$$

$$\therefore \frac{d\theta}{dt} = \theta\sqrt{a} + k$$

but $k = 0$ when $\theta = 0$

$$\therefore \frac{d\theta}{dt} \times \frac{1}{\theta} = \sqrt{a}$$

$$\therefore \frac{d\theta}{dt} = \sqrt{a}$$

when $\theta = 0$ $\quad \frac{d\theta}{dt} = -\frac{E\theta}{kl}$

$$\therefore \left(\frac{d\theta}{dt}\right)^2 = a\theta^2 - \frac{E\theta}{kl}$$

$$\therefore \frac{d\theta}{dt} = \sqrt{a\theta^2 - \frac{E}{kl}}\,\theta$$

$$\frac{d^2\theta}{dt^2} = a\theta$$

$$\frac{d^2\theta}{dt^2} \times \frac{2}{\theta}\frac{d\theta}{dt} = 2a\theta\frac{d\theta}{dt}$$

$$\left(\frac{d\theta}{dt}\right)^2 = a\theta^2 + c \qquad 2a\theta\frac{d\theta}{dt}$$

$$\frac{d\theta}{dt} = \sqrt{a}\,\theta$$

$$\frac{\frac{d\theta}{dt}}{\theta} = \sqrt{a}$$

$\log\theta = 0$

$$\frac{1}{\theta}\frac{d\theta}{dt} =$$

$$\left(\frac{d\theta}{dt}\right)^2 = -\frac{E}{MK^2l}$$

$$\frac{d\theta}{dt} = -\frac{E^{\frac{1}{2}}}{MK^2l^{\frac{1}{2}}}$$

$$\frac{d^2\theta}{dt^2} = -\theta = -\frac{l}{E}\frac{d\theta}{dt}$$

$\frac{d\theta}{dt}$ is defined by the equation $\frac{l}{E} = \theta$

$$\frac{1}{2}MK^2\frac{d\theta}{dt} = \frac{M}{2}\frac{E}{l}k\theta$$

$$MK^2\left(\frac{d\theta}{dt}\right)^2 = -\frac{E}{l}k\theta$$

$$\frac{d\theta}{dt} = \frac{E\theta}{kl}$$

$$\frac{d^2\theta}{dt^2} = -\theta\,\frac{gh}{k^2+h^2}$$

$$2\frac{d\theta}{dt}\frac{d^2\theta}{dt^2} = -2\theta\frac{d\theta}{dt}\,\frac{gh}{k^2+h^2}$$

$$\left(\frac{d\theta}{dt}\right)^2 = -\theta^2\,\frac{gh}{k^2+h^2} + c$$

$= h\theta$

$MH^2 = Mk^2\dot{\theta}^2$

$MH = Mk\dot{\theta}$

When $\theta = 0$ $\dot{\theta}$ defined by Mk

consider $Mk^2\left(\frac{d\theta}{dt}\right)^2 = Mk\theta^2$

$$\therefore \left(\frac{d\theta}{dt}\right)^2 = \frac{2Mk\theta^2}{Mk^2} = \frac{2k\theta^2}{k^2}$$

$$\therefore \frac{d\theta}{dt} = \frac{2k\theta^2}{k^2} - \theta^2\,\frac{gh}{k^2+h^2}$$

$$= \theta^2\left(\frac{2h(k^2+h^2) - ghk^2}{k^2(k^2+h^2)}\right)$$

$$\frac{d\theta}{dt} = \frac{\theta}{k}\sqrt{\frac{h(2k^2+2h^2-gk^2)}{k^2+h^2}}$$

$$\int \frac{d\theta}{\theta} = \int \frac{h\,dt}{k}$$

$$= \frac{ht}{k}$$

$$\frac{d\theta}{\theta} = \frac{h\,dt}{k}$$

$$\log\theta = \int \frac{dt}{dt}\,dt = \log\theta$$

$$\frac{d^2\theta}{dt^2} = -\frac{E\theta}{Mk^2c}$$

$$2\frac{d^2\theta}{dt^2}\frac{d\theta}{dt} = \frac{-2E\theta\frac{d\theta}{dt}}{Mk^2c}$$

$$\left(\frac{d\theta}{dt}\right)^2 = -\frac{\theta^2 E}{Mk^2c} + c$$

$$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$$

$$2\frac{d\theta}{dt}\frac{d^2\theta}{dt^2} = -2\theta\frac{d\theta}{dt}\frac{g}{l}$$

$$\left(\frac{d\theta}{dt}\right)^2 = -\theta^2\frac{g}{l} + C$$

$$\frac{Ml^2}{2}\left(\frac{d\theta}{dt}\right)^2 = Mlg\theta^2 \quad \text{but } \frac{\theta^2}{2} = \frac{s}{l}$$

$$\theta^2 = \frac{2s}{l}$$

$$\text{but } s = l\theta$$

$$\therefore s = l\theta^2$$

$$\frac{Ml^2}{2}\left(\frac{d\theta}{dt}\right)^2 = Mlg\,l\theta^2$$

$$\frac{Ml^2}{2}\left(\frac{d\theta}{dt}\right)^2 = \frac{2Mlg\theta^2}{2Ml^2} = \frac{g}{l}\theta^2$$

$$\therefore \left(\frac{d\theta}{dt}\right)^2 = -\frac{\theta^2 g}{l} + \frac{2\theta^2 g}{l}$$

$$= \theta^2\frac{g}{l}$$

$$\therefore \frac{d\theta}{dt} = \theta\sqrt{\frac{g}{l}}$$

$$T = 4\int_0^\theta \frac{d\theta}{\frac{d\theta}{dt}} = 4\int_0^\theta \frac{1}{\frac{d\theta}{dt}}\,d\theta = 4\int_0^\theta \frac{dt}{d\theta}\,d\theta$$

$$= 4\sqrt{\frac{l}{g}}\int_0^\theta \frac{d\theta}{\theta} = 4\sqrt{\frac{l}{g}}\log\theta + C$$

$$4\sqrt{\frac{l}{g}}\left(\log\theta - \log 0\right)$$

$$4\sqrt{\frac{l}{g}}\left(\log\theta - \infty\right)$$

$$2\pi = 4\sqrt{\frac{l}{g}}\int_{-\theta}^{+\theta}\frac{d\theta}{\theta} = \log\theta - \log -\theta$$

$$\frac{l}{g} = 100 \times 0.1 = 10$$

$$2g\text{'s}$$

$$s = gt^2 \qquad s = \tfrac{1}{2}gt^2$$

$$s = \tfrac{1}{2}gt^2$$

$$t^2 = \frac{2s}{g}$$

$$t = \sqrt{\frac{2s}{g}} \qquad \frac{dt}{dt^2} = \sqrt{2s/g}$$

$$v = \sqrt{2\times 10\times 960} = \sqrt{19200} = 141$$

$$\frac{s}{dt} = 1.41$$

$$\sqrt{\frac{2}{g}} = \sqrt{\frac{200}{100}} = 0.5 \qquad 3.13$$

$$\frac{dt}{dt^2} = 2\times\frac{250}{100} = 1 = \frac{100}{100} = 10.5$$

$$\frac{dt}{dt} = 4.43$$

$$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\sin\theta$$

$$2\frac{d^2\theta}{dt^2}\frac{d\theta}{dt} = -2\frac{d\theta}{dt}\frac{g}{l}\theta$$

$$\left(\frac{d\theta}{dt}\right)^2 = -\frac{g}{l}\theta^2 + c$$

when $\theta = 0$

$$\frac{1}{2}Ml^2\left(\frac{d\theta}{dt}\right)^2 = Ml\theta^2$$

$$\left(\frac{d\theta}{dt}\right)^2 = \frac{2\theta^2}{l}$$

$$\frac{f}{\xi} = \frac{g}{\xi}$$

$$\xi = \frac{g}{l}$$

$$s = l\theta$$

$$\xi = 2\theta^2$$

Anglo-American Bros. all
[illegible]
[illegible] lamp opin-
I started charging 25 amps
down to get rid of the sand lim
Normal cap 150 amp hours
Discharge a short of 15 amp
Rate down to 1.7 volts
Normal density 1.18

Commenced charging at 10.15 with
20 amperes. 43 lamps
Shut off at noon.
Started 13
Stopped 25 o'clock
Started 8.15 :25. 5.99

14 hrs × 20 = 280

0.5135 ~~Emf~~ PD = 2.0540
0.536 EMF = 2.136
.082
16) .082 (.51
2
.0051

0.628 × 4 2.512
0.590 2.360

0.622 × 4 2.488
.55 2.360
.128

E = CR R = $\frac{E}{C}$ = $\frac{0.128}{20}$
= .0064 ω

5 12
25 144 — 25
5 : 12 5.5 ×

½

0.6 × 3

1.4) 12 (10

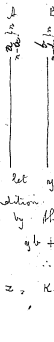
Noon	0.509	2.036	
	0.5235	2.0940	
		0.062	
2.44	amp 16.2		= .0040
15.45	.507	2.028	
	.486	1.944	
		0.084	25/32
	.075	15 amp	
16.25	0.506	2.024	
	0.484	1.936	
		0.088	0.0
	.075	15 amp	
20.00		1.870	
		1.897	
	0.071	.073	0.005
21.00		1.941	
		1.821	
		.120	
12) 120 (10 / 48	0.064	12.8 amp	0.005
		1.810	
	0.041	0.603	
		82) 1.210 (1.45 / 390 / 620	

$$z = K\left(\frac{m+n-1}{x}\right)t$$

$$z_1 = K_1\left(\frac{m+n+1}{x}\right)t$$

$$(1-x)y + z = my$$

$$y = \frac{z}{m+n-1}$$



$a > b$ $\quad m-b > n-a$

qty. which passes from A to B

= " " " " B . A

$$\propto \frac{t}{z}(a-b)$$

Let z = thickness of layer which passes then $z = K\frac{t}{z}(a-b)$

Now let y be the thickness of the layer in condition B which in time t will be reduced by the diffusion to condition A

Then $yb + z = ya$ $\quad$ or $ya + z = yb$

$$\therefore y = \frac{z}{a-b} \qquad y = \frac{z}{b-a}$$

but $z = K\frac{t}{z}$

K is the thickness of the layer of substance which in unit time would be raised to the temperature of the substance unit distance upgrade by the heat passing in the interval

$$18 \times 10^7$$

$$r = \frac{1}{18 \times 10^7} = \frac{1}{\cdot 18 \times 10^9} = 5 \times 10^{-9}$$

$$44{\cdot}2 \times 10^7$$

$$r = \frac{1}{44{\cdot}2 \times 10^{-7}} = \frac{1}{0{\cdot}442 \times 10^{-9}} = 2 \times 10^9$$

$$\begin{array}{r} 44{\cdot}2)\ 1000{\cdot}0000(226 \\ 1160 \\ \hline 3766 \end{array}$$

$x = +1$ $\quad 1 - 6 + 10$

$1 - 5$

$-5 + 5 \quad y = 5$

$x = +2$ $\quad 1 - 6 + 10$

$2 - 8$

$-4 + 2 \quad y = -2$

$x = +3$ $\quad 1 - 6 + 10$

$+3 \mp 9$

$-3 + 1 \quad y = +1$

$x = +4$ $\quad 1 - 6 + 10$

$+4 - 8$

$-2 + 2 \quad y = +2$

$x = +5$ $\quad 1 - 6 + 10$

$+5 \mp 5$

$-1 + 5 \quad y = 5$

$x = 6$ $\quad 1 - 6 + 10$

$+6 \quad 0$

$0 + 10 \quad y = 10$

$x = 0$ $\quad 1 - 6 + 10$

$-16 + 10 \quad y = 10$

$x = -1$ $\quad 1 - 6 + 10$

$-1 + 7$

$-7 + 17$

$x^2 - 6x = -10$

$x^2 - 6x + 9 = -1$

$(x-3)^2 = \sqrt{-1}$

$x = 3 \pm \sqrt{-1}$

$y = 0$ $\quad 1 - 6 + 10 \quad x^2 - 6x + 10 = 0 \quad x = 3 \pm \sqrt{-1}$

$y = -1$ $\quad x^2 - 6x + 10 = -11$

$x^2 - 6x + 9 = -21$

$x - 3 = \sqrt{-1} \times \sqrt{21}$

$x = 3 \pm 1.4\sqrt{-1}$

$x^2 - 6x + 9 = 0.9$

$x^2 - 6x + 9 = -9.1$

$x = 3 \pm 1.4\sqrt{-1}$

$x = 3$

$y = -3$ $\quad x - 3 = 1.7\sqrt{-1}$

$x = 3 \pm 1.7\sqrt{-1}$

$x = 3 \pm 1.7\sqrt{-1}$

$y = 1$ $\quad x^2 - 6x = -9$

$x^2 - 6x + 9 = 0$

$x - 3 = 0$

$x = 3$

$7 \overline{)10.7}$

$x^2 - 6x = -9.9$

$x^2 - 6x + 9 = 0.1$

$x - 3 = \sqrt{-1}$

$y = 0.5$ $\quad x^2 - 6x = -9.5$

$x^2 - 6x + 9 = -0.5$

$x - 3 = \sqrt{-1} \times 0.7$

$x = 3 \pm 0.7\sqrt{-1}$

$6 \overline{)10.38}$

$x^2 - 6x + 10 = 0.9$

$x^2 - 6x = -9.1$

$x^2 - 6x + 9 = -0.1$

$(x^2 - 3)^2 = \sqrt{-1} \times \sqrt{0.1}$

15 cm

10 cm

$$(a+d+f)\{-b+b+c+f\} - af - f^2$$

$$(a+d+f)(c+f) - af - f^2$$

$$\cancel{af} + df + \cancel{f^2} + ac + dc + fc - \cancel{af} - \cancel{f^2}$$

$$c(a+d) + f(c+d)$$

$$ab = cd$$

$$d = \frac{ab}{c}$$

$$ab^2k(a+d) + f(c+d)$$

$$c\left(a + \frac{ab}{c}\right) + f\left(c + \frac{ab}{c}\right)$$

$$ac + ab + cf + \frac{ab}{c}$$

$$-fb - a + ab - ac - af$$

$$ab + ac + af + bf$$

$$f(a+b) - f(c+d)$$

$$u(2b+a) + sa + sb + lb = ab^2k$$

$$u = \frac{ab^2k + -s(a+b) - lb}{2b+a}$$

0.1977

02400 1977 = 121
04230
5760

9000 : 1979 - 496
18920
11270

4000 : 1977 · 202
4600

9500 : 1977 · 480
189200
10040

5500 : 1977 · 278
15460
16210

5900 : 1977 - 298
19460
16670

4900 : 1977 · 247
9460
15520

6500 : 1977 = 328
5690
17360

9400 : 1977 · 475
19920
10870

7200 : 1977 · 364
12690
8280

7800 : 1977 = 394
15690
8970

8500 : 1977 · 445
8920
9920

10000 : 1977 = 525
5150
11960

11000 : 1977 = 556
11950
12650

12500 : 1977 = 622
4380
4260

13200 : 1977 = 667
13380
15180

14200 : 1977 = 718
3610
16330

16100 : 1977 = 814
3840
8630

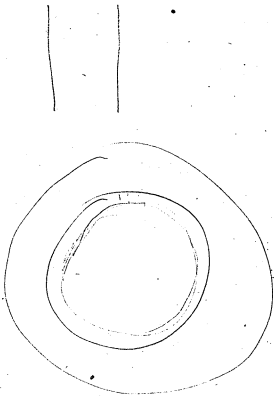
17500 : 1977 = 885
16840
10240

18200 : 1977 = 950
10070
1850

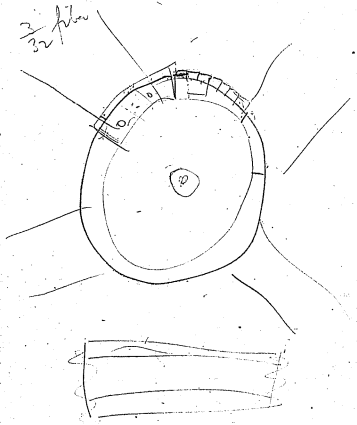
5000

14 X 33

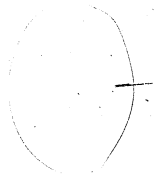
462,000



3/32 film



.75
90



0
12.5
5000
8000

5000
85.

10000
13000

17" 1 1/2" X 90 X 3/4

9/16 × 90 810/16 = 51
12
612
100 lbs

11. XI. 89.

air	+	0.400	3.761
	=	0.400	3.740
bet poles	=	0.450	3.730
	+	0.430	3.757
47 lamps	=	0.030	3.758
	+	0.077	3.726
1 lamp	+	0.147	3.727
	=	0.072	3.757

T.B 24.3 °C

1000/10

1.5 0 4 4

0.00 15 1496

0.1944
0.194
7.66 2

10.20 on ~~[illegible]~~ correct unit

0.1823

766) 1823 (2.38
2910
6120

23.8 milliampere.

40 milliampere allowed

Nov. 16. 89
Resist. of Diff. Galvanometer
- 5380 ω
5381 ω 21.5°C

10000 / 100

7.147
.072
7.075

1.125

16.4
16.4
16.5

100000/100	no knot	16.542	0.120
	1 –	16.402	0.121
	2 –	16.380	0.121
	no + 1 ‖	8.243	0.243
	no 1 + 2 ‖	5.509	0.366
	no + 1 2 sh. coll ‖	8.235	0.243 no white on [illegible]
	no 0 1 + 11 sh. coll	16.445	0.121 [illegible]
	0 + 1 – –	32.687	0.245
	no ch.	32.687	0.0
	all sch.	49.267	0.367
	0 + 1 no head.	16.402	0.245
			−0.002

877
31
877
2631
27177

9.9 one bulkhead diam flange 6.35
length over all 10.6
bulkhead diam 1.9 2.15 cylinder
not diam over curve 6.15
wire 0.095
48 turns triple per layer
Mt 1090 g. 29 layer
weight 30

9

#1 end	6 cms	× 1.5	30 hours	
# 2 -	5.9 -	× 1.4	32	
# 3.	5.85	× 1.4	30 -	
# 4	5.85	× 1.5	31 -	

96.3 divs represents $1.424 \times 10^{8} \times 1.0 \times 10^{-13}$ sp

1 - - 1.424×10^{-5} -

9.0	× 30 =	270	sq. cms
8.26	× 32	264.32	-
8.19	× 30	245.7	-
8.77	× 31	271.87	-

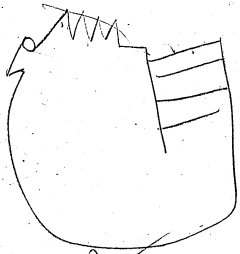
Nov. 23

5.83 ω
0.407 MF without core

5.83 ω
3.02 MF } with core
0.10 ω = Leads

8. 12. 89

55.5 volt	57°	leads	4.2
110.0	150°	amperes	2.07
			2.13



10

-35	1	-1	-27	+25	+5	22·1875 22.53125
2.25 11.75		-3.5	+15.75	+39.375	-220.3	
5.625 39.375		-4.5	-11.25	+64.375	-220.3	16·9375 132.5625
1.25 2.75	1	-1	-27	+25	+5	
0.125 63.375		+3.5	+8.75	-63.375	-132.06	
		+2.5	-18.25	-37.875	-127.06	
1.75 15.75	1	-1	-27	+25	+5	-25.625 12.8125 11.53125
-11.25 8.625 10.625		+4.5	+15.75	-50.625	-115.31	
		+3.5	-11.25	-25.625	-110.3	

$x^4 - x^3 - 27x^2 + 25x + 5$

$x = 0 \qquad y = +5$

$x = 1$

1	−1	−27	+25	+5	
	+1	0	−27	−2	
	0	−27	−2	+3	$y = 3$

$x = 2$

1	−1	−27	+25	+5	
	2	+2	−50	−50	
	+1	−25	−25	−45	$y = -45$

$x = 1.5$

1	−1	−27	+25	+5	
	1.5	+0.75	−39.375	−21.5625	
	+.5	−26.25	−14.375	−16.5625	$y = -16.5625$

$x = 1.2$

1	−1	−27	+25	+5	
	+1.2	+0.24	−32.016	−5.1664	
	+0.2	−26.76	−7.016	−3.1664	$y = -3.1664$

$x = 1.1$

1	−1	−27	+25	+5	
	+1.1	+0.11	−28.579	−2.2369	
	+0.1	−26.89	−2.579	−2.2369	$y = -2.2369$

$x = 3$

1	−1	−27	+25	+5	
	+3	+6	−63	−114	
	+2	−21	−38	−109	$y = -109$

$x = 4$

1	−1	−27	+25	+5	
	+4	+12	−60	−140	
	+3	−15	−35	−135	$y = -135$

$x = .5$

1	−1	−27	+25	+5	
	+.5	+20	∓ 35	−50	
	+.4	−7	−10	−45	$y = -45$

$x = 6$

1	−1	−27	+25	+5	
	6	+30	+18	208	
	+5	+3	+43	+363	$y = +363$

$x = 7$

1	−1	−27	+25	+5	
	7	+42	+105	+910	
	6	+15	+130	+915	$y = +915$

$x = -1$

1	−1	−27	+25	+5	
	−1	+2	+25	−50	
	−2	−25	+50	−45	$y = -45$

$x = -2$

1	−1	−27	+25	+5	
	−2	+6	+42	−134	
	−3	−21	+67	−129	$y = -129$

$x = -3$

1	−1	−27	+25	+5	
	−3	+12	+45	−210	
	−4	−15	+70	−205	$y = -205$

$x = -4$

1	−1	−27	+25	+5	
	−4	+20	+28	−212	
	−5	−7	+53	−207	$y = -207$

$x = -5$

1	−1	−27	+25	+5	
	−5	+30	+15	−200	
	−6	−3	+40	−195	$y = -195$

$x = 0.5$

1	−1	−27	+25	+5	
	0.5	−0.25	−13.625	+5.8875	
	−0.5	−27.25	+11.375	+10.8875	

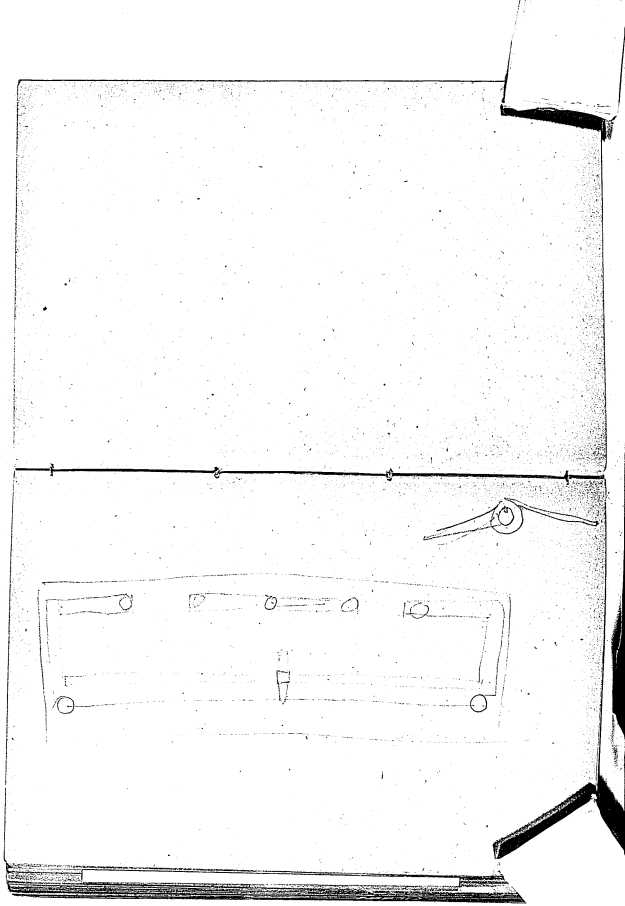
$x = 0.25$

1	−1	−27	+25	+5	
	+0.25	−0.1875	−6.7969	+5.55	
	−0.75	−27.1875	+18.2031	0.55	

$x = 0.75$

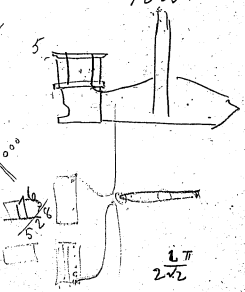
1	−1	−27	+25	+5	
	+0.75	−0.1875	−20.391	+3.8219	
	−0.25	−27.1875	+4.1093	8.822	

6.7969 1.0273
20.3907 3.0819



$$L = \frac{24 \times 2 \times 1 \times 52}{2 \times 12}$$

45
52
90
240
2496
100 ft



$\frac{i\pi}{2\sqrt{2}}$

1.414
2828 | 314
314 | 2

37,800
1,200
9,000

123
800
98400 | 139
246
2980
2288
6540

246 |

3142 | 2828 | 9
620